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Diesel Railway Traction

Canadian National Experience

IT is only the quite exceptional conditions under which the railcars of the Canadian National Railways are worked which have prevented their being held up as a model of what diesel traction will do over a number of years. These conditions, of course, are not so much peculiar to the Canadian National system as to the North American Continent generally, but they are so vastly different from conditions in Europe and countries under European control, that useful comparison is hardly possible if the vehicles be considered as a complete stud. On the other hand, nine years' operation has proved very definitely that light engine-weight does not necessarily mean high maintenance cost when the power unit is installed in a railcar, and this refutes the argument frequently put forward that slower running, heavier engines are preferable if reliable operation is to be obtained. The use of a light compact power unit further enables the production of a vehicle having a good operating ratio.

An interesting statement in Mr. Gage's article on the operation of the Canadian National railcars, published elsewhere in this issue, is that of the proportions of the total failures debited against the various equipments. The table reproduced is useful as an indication of what may be expected from heavy railcars operated under onerous conditions, and its value is enhanced in that it was compiled from data obtained from no fewer than 28 railcars while covering a mileage of almost three and a half million. That the mechanical equipment is responsible for only one-eighth of the failures is a tribute to the soundness of the design, but it is probable that the proportion is much higher in the ultra-light diesel railcars now at work in large numbers in Europe. One of the most important points put forward by Mr. Gage is the necessity of using a fuel suitable for the engine, and whose specification is drawn up more upon a base of chemical characteristics rather than upon viscosity and gravity. We suggest that the deleterious effects of the use of even a slightly unsuitable fuel have not been fully realised.

Could it be Done with the Diesel?

MR. L. H. POMEROY, in his paper on "Automobile Transmission Systems," to which we briefly referred in the last issue of this Supplement, shows that he possesses that rare faculty which enables some engineers to deal in a practical manner with problems in hand, while keeping in sight such developments as are likely to suggest totally different solutions to the same problems in the near future. Thus, while describing many transmissions and making a practical study of them, he does not overlook the possibility that with increasing engine flexibility the torque converting transmission unit may eventually become unnecessary. He explains that the speed range of modern petrol engines is now so great that, except for starting and stiff hills, the gearbox is practically functionless. He makes the very interesting observation that given "sensible road construction" permitting a really high speed, and a correspondingly high wind resistance, larger engines would be in common demand. Under such conditions the need of a torque converter would disappear. We would point out that a railway is "sensible" in that it does permit continuous high speed. Also the gradients are far below the figure quoted by Mr. Pomeroy as being climbable by the modern car in top gear. Assuming, then, that only a moderate initial acceleration is required—and nothing more is really necessary except on services with frequent stops—the transmission might be simplified down to a clutch or a fluid coupling, or to a combination of both, with, of course, the final gear reduction incorporating facilities for reverse. In some high speed Continental railcars driven by petrol engines the transmission has actually been cut down in this way. Whether a similar simplification will be possible in the diesel railcar remains to be seen. Everything depends on the speed range of the engine under approximately full load torque.

What is the Power Limit?

SINCE the Beardmore-engined articulated locomotive of 2,660 b.h.p. was built for the Canadian National Railways some six years ago, no further advance in power has been recorded in diesel traction, and one has become accustomed to think of the commercial limit as being in the neighbourhood of 1,800 to 2,000 b.h.p. with present types of construction, for the Canadian locomotive was admittedly experimental, and is now running as two separate 1,330 b.h.p. units. Sundry experiments have been made with single engines to develop up to 1,800 b.h.p., but, in general, anything over 900 b.h.p. has required the use of two engines. Although pleas have been put forward that this method gives maximum reliability in that the vehicle can work home on one engine should the other fail, we think that, however useful and in certain cases, however efficient, this may be, it is more or less of an excuse, and is dangerous to put forward as an argument for diesel traction in the same breath as a statement that the new form of motive power is well past the experimental stage. Recent tendencies have been to produce a locomotive of over 2,000 b.h.p., which is not surprising, especially in countries such as North America, where 1,000 b.h.p. in a locomotive is of little use for anything but shunting work. Single engines are now commercially available for 1,330, 1,450, and 1,600 b.h.p., and two of these in an articulated unit will give a maximum of 3,200 b.h.p. Designs are also extant for single engines up to 3,000 b.h.p., but in the most powerful diesel locomotive now at work, *viz.*, the new Russian 2-Do-1+1-Do-2 locomotive, two 1,200 b.h.p. oil engines are installed. The P.L.M. Railway has been enquiring for a main line locomotive of 3,500-4,000 b.h.p., and from the tenders put forward it seems as if this output will be attained with only two engines, although in some cases, at least, each engine will have a double crankshaft driving a single electric generator through gears. For fast service such a locomotive could hardly be constructed with fewer than 12 axles, assuming a maximum axle load of 20 tons, and spring-supported traction motors driving through a quill are almost axiomatic.

DIESEL VEHICLES OF THE CANADIAN NATIONAL RAILWAYS

During the last nine years 28 railcars and 4 locomotives have been introduced

IT was primarily at the instigation of the late Mr. C. E. Brooks, then Chief of Motive Power, that the Canadian National Railways in 1924 commenced an investigation into the possibilities of diesel traction. After an exhaustive study had been made of all the available types of oil engine it was decided to employ the Beardmore high-speed light-weight engine which had been developed for the Air Ministry. Modifications to the design to suit it for railcar work were undertaken by Beardmore's, and on September 22, 1925, the first 200 b.h.p. diesel-electric railcar was put into service. It was followed six days later by the first of the two 400 b.h.p. articulated railcar units. In 1927, five 300 b.h.p. railcars were acquired, and in 1930 and 1931 a number of 300 and 350 b.h.p. railcars with Westinghouse-Beardmore oil engines were set to work. Main details of all of these cars will be found in the accompanying table and in the arrangement drawings of the 200 and 400 b.h.p. vehicles.

Car No.	Engine	B.h.p.	Length of car, ft.	No. of seats	Baggage space	Weight, Engl. tons
15817–15818	Beardmore 8-cyl.	400	102	126	Yes	85·7
15819–15825, 15831	Beardmore 4-cyl.	200	60	57	Yes	48·0
15826–15830	Beardmore 6-cyl.	300	73	57	See note*	63·0
15832–15840	Westinghouse-Beardmore 6-cyl.	350	73			63·5
15841–15844	Westinghouse-Beardmore 6-cyl.	300	73			63·0

* Some cars have baggage compt., and one car is for baggage and mails only.

Particulars of their operation and further illustrations will be found elsewhere in this issue, in an article by Mr. R. G. Gage, the Electrical Engineer of the Canadian National, who has been closely connected with the development of diesel traction on that line for the past decade. The 28 railcars, to the end of 1933, covered an aggregate of approximately $6\frac{3}{4}$ million miles, of which the first 200 b.h.p. unit accounted for 450,000 miles, and the eight vehicles of this class for almost $2\frac{3}{4}$ million miles.

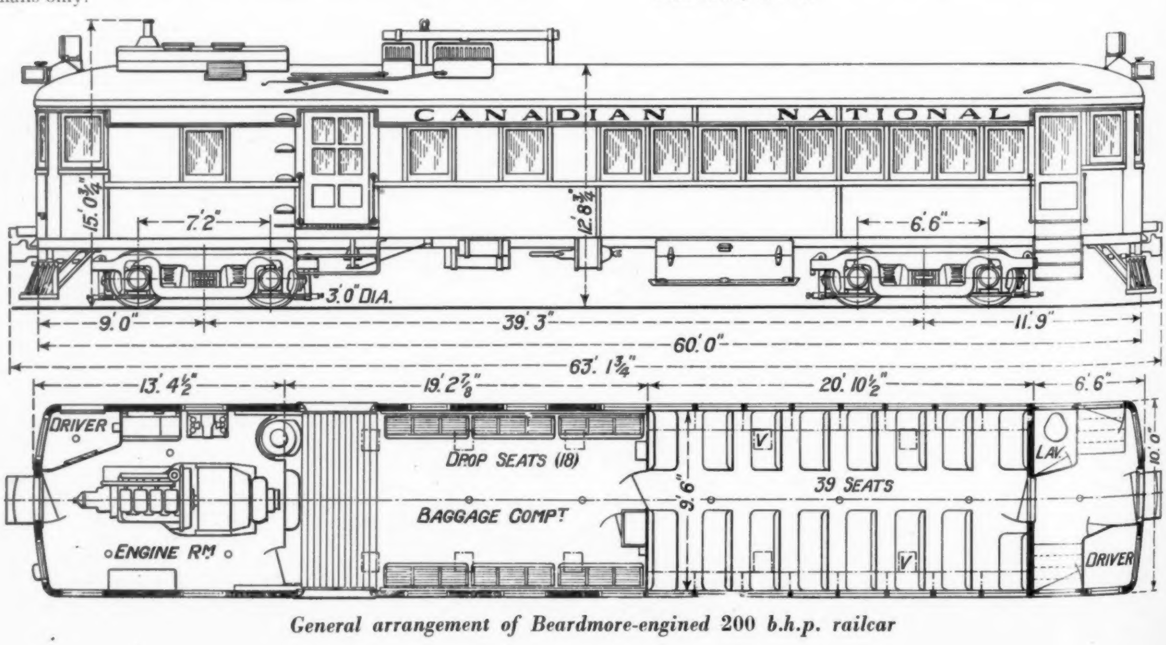
The 300 b.h.p. Westinghouse-Beardmore engines introduced in 1930 incorporated modifications which experience with the 1927 Beardmore engines showed to be desirable. Leading particulars of the two power units are as follow:—

	Westinghouse	Beardmore
No. of cylinders	6	6
Bore and stroke, in.	9·0 × 12·0	8·25 × 12·0
R.p.m.	800–1,000	800–1,000
B.h.p...	350 normal 450 max.	300 normal 350 max.
Engine bed weight, lb.	3,200	3,131
Engine weight, lb.	5,900	5,780
Flywheel weight, lb.	1,000	1,056
Generator weight, lb.	7,100	
Total weight, lb.	17,200	
Crankshaft diameter, in.	5·0	4·75

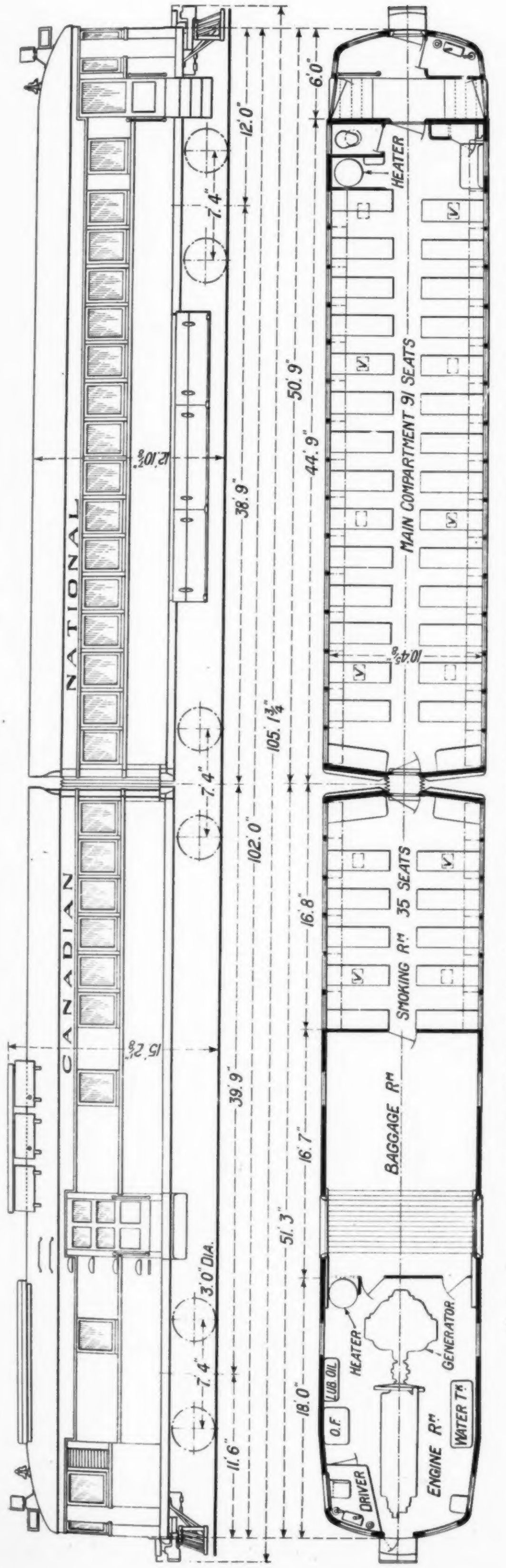
The total length of the Westinghouse engine is approximately 2 ft. 6 in. shorter than that of the Beardmore unit, this being chiefly due to the redistribution of the governor and fuel pumps.

Main Generator—
Continuous rating .. .. 400 volts 750 amp. at 900 r.p.m.
One hour .. .. .. 500 volts 600 amp. at 900 r.p.m.
Maximum speed .. .. 1,150 r.p.m.
Maximum voltage .. .. 750.
Generator windings not to exceed 120° F. above air temperature.

Traction Motors—
250 volts 60 amp.
Total h.p. at 740 r.p.m. = 340, self-ventilated.
Gear ratio, 59 : 20.



General arrangement of Beardmore-engined 200 b.h.p. railcar



General arrangement of 400 b.h.p. Beardmore-engined articulated diesel-electric railcar, Canadian National Railways

Statistics of Operation: Five 6-Cylinder Canadian National Railcars over a Period of Six Months

Revenue—	$
Passenger	124,535·29
Mail	20,496·48
Milk	333·00
Express	31,354·48
Total	176,719·25
Expenses—	
Supervision	2,915·96
Car repairs	2,845·83
Engine and transmission repairs	24,048·74
Total maintenance and repairs	29,450·53
Wages of drivers	11,881·92
Wages of train-crew	13,904·55
Fuel	5,571·52
Lubricants	6,000·78
Other supplies	6,573·81
Total operating expenses	43,932·58
Total operating and maintenance costs	73,383·11
Net operating revenue	103,408·14
Statistics—	
Motor-car miles	174,024
Trailer miles	237,033
1,000 ton-miles (short tons)	23,299
No. of motor-car days in operation	588·0
Average daily mileage	296·0
Total number of men in the crews	81
Number of passengers carried	106,556
	cents.
Revenue per motor-car mile	101·50
Revenue per passenger	116·90
Car repairs per motor-car mile	1·42
Engine and transmission repairs per car-mile	13·81
Supervision per motor-car mile	1·67
Fuel per motor-car mile	3·2
Lubricant per motor-car mile	3·44
Total cost, excluding interest and depreciation per car-mile	42·16
Total operating cost per 1,000 ton-miles	315·00

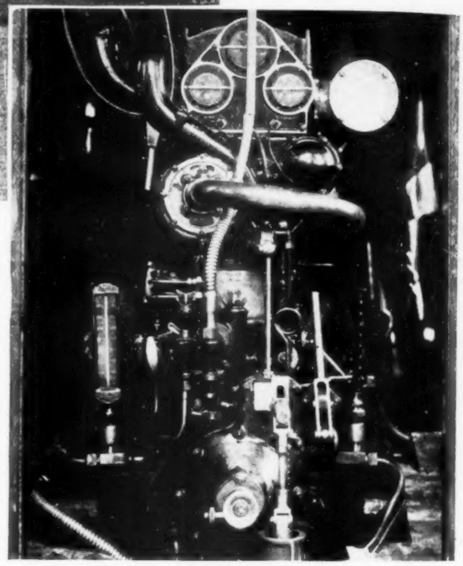
Supplementing the information given by Mr. Gage as to the performance of the railcars, we reproduce with this article a table showing the operating revenue and expenditure of five of the six-cylinder railcars over a period of six months early in their existence.

Experience with diesel-driven main-line locomotives on the Canadian National Railways is confined to the well-known 2,660 b.h.p. 2-Do-1+1-Do-2 locomotive with two 12-cylinder Beardmore engines, several views of which are given in Mr. Gage's articles. After operation on various services this locomotive was withdrawn for modifications similar to those outlined when describing the railcars, but is now running again, although in two separate units. The main dimensions of each 1,330 b.h.p. half are given in the following table, which also includes particulars of the two oil-electric shunting locomotives owned by the Canadian National.

Leading Characteristics of C.N.R. Locomotives

No. of locomotives	2	1	1
Wheel arrangement	2-Do-1	Bo + Bo	Bo — Bo
Duty	Main Line	Shunting	Shunting
Engine make	Beardmore	Westinghouse-Beardmore	Ingersoll-Rand
Total b.h.p.	1,330	400	600
Wheel dia., in.	51	38	43
Total wheelbase, ft. in.	37–8	23–0	30–6
Length over buffers, ft. in.	47–0	33–10½	44–0
Max. tractive effort, lb.	50,000	42,000	63,600
Adhesion weight, Engl. tons	107·0	62·5	106·0
Total weight, Engl. tons	145·0	62·5	106·0
Max. speed, m.p.h.	63	40	40

Left: *Beardmore 400 b.h.p. articulated oil-electric railcar at Kincardine, Canadian National Railways. The car now operates without the trailer shown in the illustration*



Below: *End view of eight-cylinder 400 b.h.p. oil engine installed in articulated railcar built in 1925*

OIL-ELECTRIC TRACTION ON THE CANADIAN NATIONAL RAILWAYS

A valuable review of the difficulties encountered and the actual costs incurred during eight years of operation

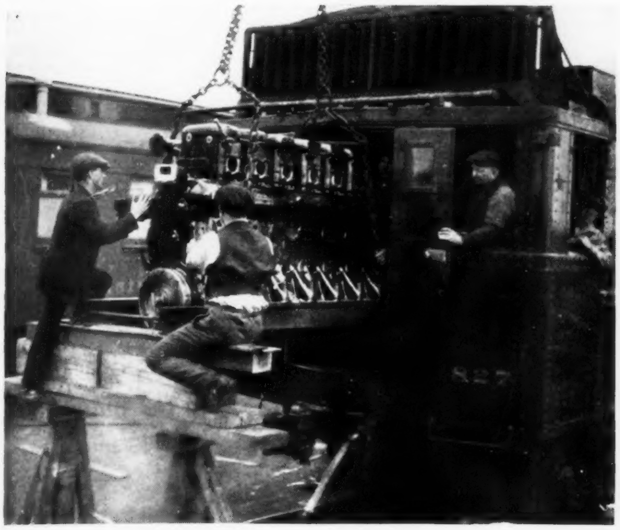
By R. G. GAGE, Chief Electrical Engineer, C.N.R.

REALISING the opportunity for saving in the operation of branch lines and other minor services, and having tried successively the converted road bus, the storage battery car, and the petrol-mechanical railcar, and all to a considerable extent, the management of the Canadian National Railways in 1925 entered upon an extensive programme for the application of the oil engine. This decision has resulted in the use to-day of 32 railcar and locomotive units ranging from 200 to 1,330 b.h.p. capacity.

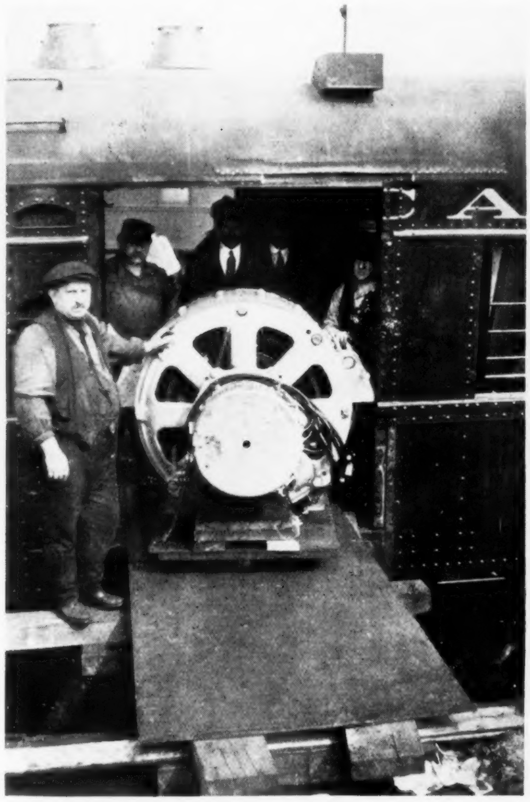
As a direct result of their development work for the Air Ministry, William Beardmore & Co. Ltd. were able to offer in 1925 a light weight, high speed engine which, with a directly connected generator, seemed to meet all the requirements of the unit railcar service. This was an 8¼ in. by 12 in. engine developing 50 b.h.p. per cylinder when running at 800 r.p.m., and was purchased in four and eight cylinder arrangements, as shown with detail dates on the mileage chart accompanying this article. The two eight-cylinder engines were designed to operate at constant speed, whereas the next seven four-cylinder engines have an operating range from 300 r.p.m. when idling to 750 r.p.m. at full speed.

It is particularly interesting to note to-day, when so much is being talked of articulated trains and the multiple-unit operation of several power units, that the two railcars in which the 400 b.h.p. engines were installed, were built each with two car bodies articulated on a centre truck, and both fitted with an electrical control which would permit a coupled train of 800 b.h.p. to be operated from any one of four driving positions. The capacity of this train was 252 passengers and 3,000 cu. ft. of baggage space, which gives a weight of 1,490 lb. per passenger. Except for special runs and as demonstrations, these two cars have been operated separately and the multiple-unit control feature has been abandoned. As a further comparison of the train weight to paying load ratio, the original four-cylinder cars and trailer represents 1,428 lb. per passenger and 1,800 cu. ft. of baggage space. These weights compare favourably with recent trains in the United States and on the Continent.

The engine weighs 17 lb. per b.h.p. without the underbed, or 45 lb. per b.h.p. with the underbed and generator. This low weight, remarkable for the time, was made possible by very careful design, and the scientific use of materials and excellent workmanship. The performance curves below indicate the results of this policy. The next lot of engines was built by Beardmore in 1927 with the same bore and stroke, developing 300 b.h.p. and operating from 300 to 800 r.p.m. These engines, however, were heavier and embraced all the points which experience seemed to indicate as improvements. Later experience raises a doubt as to some of these. Seven million car miles in service does not suggest that light weight is in itself a cause of increased repairs. These engines weigh 23 lb. per b.h.p. without the underbed, or 59 lb. per b.h.p. with the underbed and generator. In 1929, the Westinghouse Electric & Manufacturing Co. built in Philadelphia, by arrangement with Beardmore, seven 350 b.h.p. engines with cylinders 9 in. by 12 in., which also operated at 300-800 r.p.m. These were likewise heavier than the original Beardmore engines and weigh 23 lb. per b.h.p. without the underbed, or 50 lb. per b.h.p. with the under-



Above: Putting a Beardmore six-cylinder 300 b.h.p. oil engine into one of the 73 ft. cars, Canadian National Railways

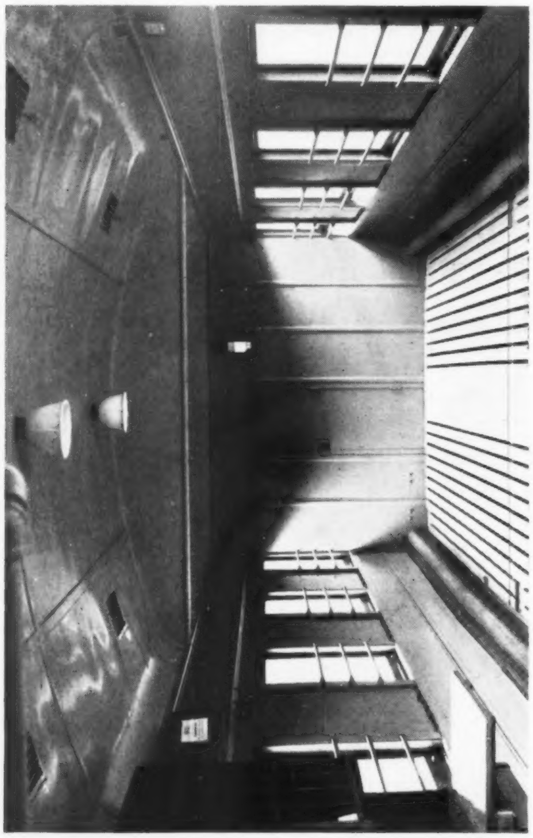


Right: A Westinghouse direct-current generator being installed in one of the 300 b.h.p. double-bogie diesel-electric railcars

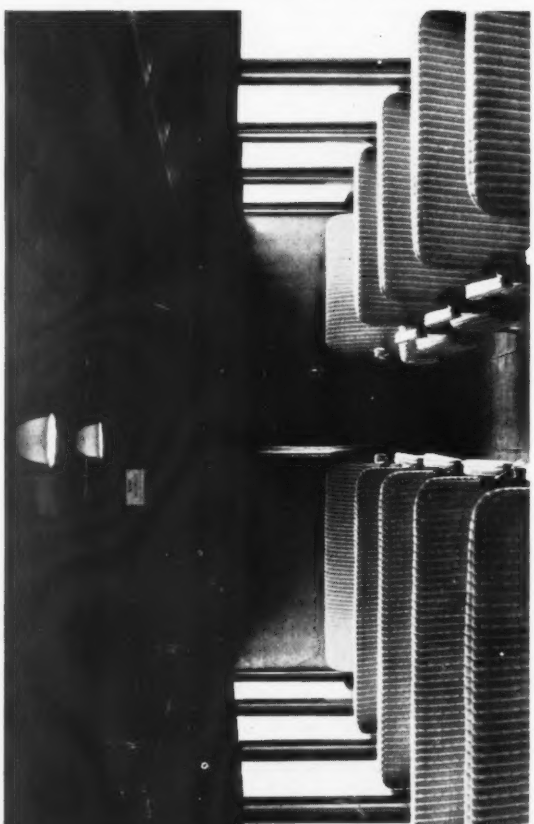
bed and generator. Again, these engines embraced features of design which the operation of the Beardmore engine seemed to indicate as improvements. The bearings were enlarged to decrease the unit loading; the increased length of the engine permitted a larger cylinder diameter; the connecting rods were made more rigid at the bottom end: several methods of babbitting the big ends were tried, including tin-base babbitt direct on the steel rod, without the use of shells: and Westinghouse fuel pumps were applied, embodying a combined pump plunger and control valve for each cylinder instead of the switch valve and separate pump and control valve for each two cylinders, as used on all of the Beardmore engines. The last lot of four engines were the Beardmore $8\frac{1}{4}$ in. by 12 in. type manufactured under licence by Westinghouse.

The diversity of the equipment, as briefly indicated above, has undoubtedly added to the value of the experience, but it has not helped in securing efficient operation. Besides the mechanical differences, the arrangement of motor connections and the electric control also differs. In the two articulated cars, the four traction motors are connected permanently in parallel across the generator. As the generator runs at constant speed, its voltage is varied by changing the generator field strength, which is supplied by storage battery. On the 60-ft. cars with the four-cylinder engines, the two motors are connected with the International General Electric type K control and operate in the series, parallel and shunt field positions. The engine speed is raised from idling to 750 r.p.m. at each of these running positions. The differential field winding

General view of 60 ft. railcar with 200 b.h.p. four-cylinder Beardmore engine



Interior of luggage compartment, 300 b.h.p. railcar



Interior of passenger compartment, 300 b.h.p. railcar

on the B.T.H. generator is counted on to prevent overloads on the engine. On all of the 73-ft. cars with the six-cylinder engines, the two motors are connected in parallel and the applied voltage is controlled by varying the strength of the auxiliary generator field. Some of the cars have a shunted field position on the motors for high speed running. On all of the cars which have Westinghouse electrical equipment, the engine is protected from overload by a torque motor or relay which reduces the generator load by introducing resistance into the auxiliary generator field, when the engine capacity has been reached.

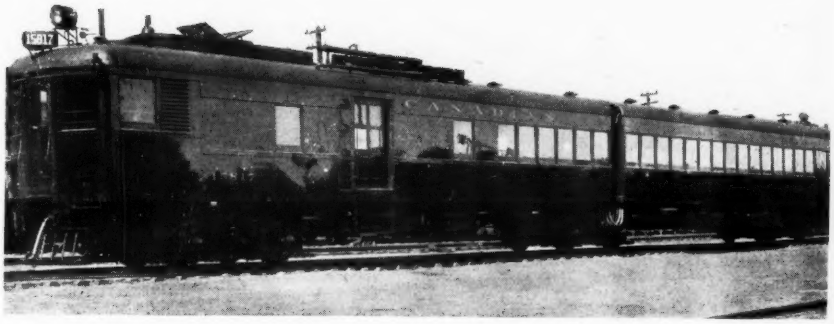
In presenting the operating data, the quantities and costs are given in detail for the last nine 350 b.h.p. railcars and for the original eight 200 b.h.p. railcars, and are offered as an indication of what may be expected under similar conditions. It must be kept in mind, however, that these cars are operated in territories far remote

One of the early 200 b.h.p. railcars, Canadian National Railways

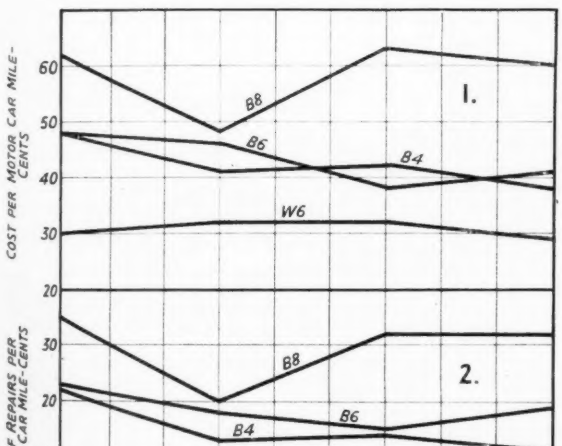
from each other and from regional and system headquarters, and by the very nature of their services are on runs having in many cases the poorest of maintenance facilities. The mere question of periodical wheel turning may easily involve time out of service greatly in excess of the time actually necessary for the work. The point has never been reached where spare cars are available for replacement during shopping periods.

Although no special shop has been assigned to diesel engine work alone, the manufacture and repair of parts requiring accurate workmanship and experience is confined to one shop and the periodical general overhaul of the whole equipments is performed in the main shops at Moncton, N.B., Montreal, Que., Stratford, Ont., and Winnipeg, Man. Weather conditions, as well as the lack of concentration of the services, work against efficient operation, and when railways having an equal number of cars in operation, but maintained at one point and by one organisation, show a higher operating efficiency, they must

Right: One of the two 400 b.h.p. articulated oil-electric railcars put into service in 1925 on the Canadian National Railways



Below: Operating data relating to four types of Canadian National oil-electric railcars



in all fairness make due allowance to the geography of the Canadian National situation. It has not yet been possible to establish a school for the education of the operating and maintenance forces on the oil engine equipments, as in the case of some European railways, but a great deal of effort has been expended (notwithstanding the comments of certain friendly Continental critics to the contrary) in education by means of published instructions and personal supervision.

The total mileage made in 1933 by the 28 railcars was 1,152,166 at an average cost of 38 cents per train mile. It is thus readily seen what the total saving was as compared with steam operation. Interest and depreciation has not been included. The following tabulation shows the results of the nine most recent cars fitted with Westinghouse six-cylinder engines, and the eight original cars fitted with Beardmore four-cylinder engines, the three main items being the cost per train mile, availability (availability is the ratio of serviceable time to scheduled time), and the cost of motor repairs per motor car mile:—

AVERAGE OPERATING DATA FOR YEAR 1933

—		Westinghouse 350 b.h.p. (9 cars).	Beardmore 200 b.h.p. (8 cars).
1. Railcar miles		474,447	317,462
2. Trailer car miles		430,375	195,846
3. 1,000 ton-miles		53,621	24,141
4. Days scheduled		2,587	2,455
5. Days serviceable		2,130	2,243
6. Availability	per cent.	82	91
7. Average daily miles		225	142
8. Number of men in crew		3	3
9. Gallons of fuel		171,077	74,768
10. Average miles per gallon (fuel)		2·8	4·0
11. Gallons per 1,000 ton-miles (fuel)		3·2	3·1
12. Gallons of lubricating oil		6,301	6,465
13. Average miles per gallon (lub.)		75·3	49
14. Ratio lub. oil to fuel	per cent.	4	9
15. Cost per gallon—fuel	cents	9·3	9·6
16. " " " —lub. oil	"	76·0	73·0
17. Supervision per railcar mile	"	0·57	0·52
18. Car repairs " " "	"	0·82	1·70
19. Motor repairs " "	"	8·48	8·93
20. Wages—enginemen per railcar mile	"	5·93	7·96
21. " —trainmen " " "	"	7·60	12·15
22. Fuel oil per railcar mile	"	3·35	2·25
23. Lub. oil (crankcase) per railcar mile	"	1·00	1·47
24. Other oils and greases " "	"	0·03	0·05
25. Other supplies " " "	"	1·78	3·10
26. Total operating cost per railcar mile	"	29·56	38·18
27. Total operating cost per 1,000 ton-miles	dollars	2·62	5·02

Note: Gallons and tons in American measure

It will be noted that the sum of the fuel and lubricating oil for the two cars is about the same, and also the cost of repairs. If the difference of 7·9 cents in crew wages and other supplies is deducted from the Beardmore total,

the costs per train mile are on a comparative basis and are almost equal. This difference in crew wages and other supplies is due to working conditions and wage schedules as affected by the daily mileage and is not a part of the mechanical maintenance or operation. The writer claims that these figures support the statement above that light engine weight is not in itself the cause of increased engine repairs.

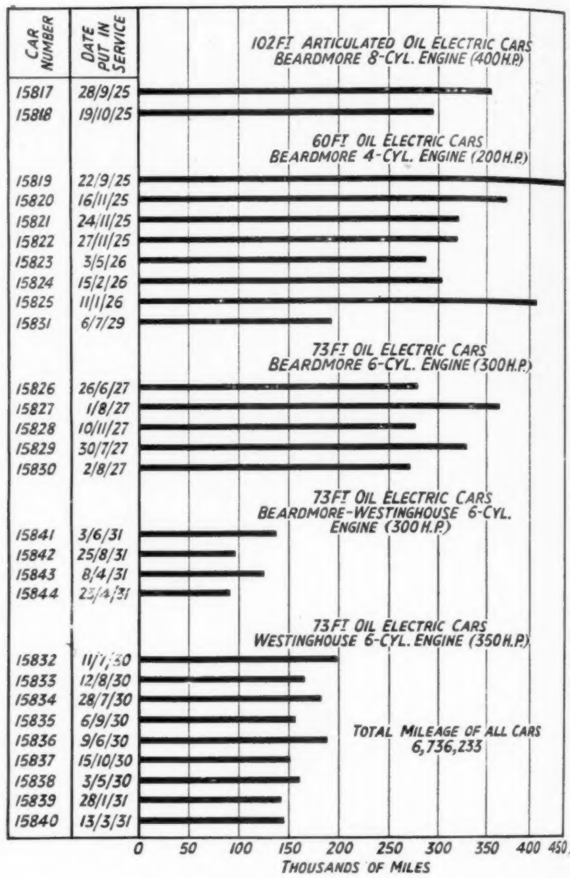
In order further to indicate the performance of the four types of railcars, the most important factors of the cost for the last four years are shown in the accompanying diagram. Curves 1 and 2 show that the repairs and total cost are generally constant with a slight downward trend. The exception is the articulated cars with the Beardmore eight-cylinder engines. These are consistently higher, probably because there are only two cars of this type, and they are special in every regard, with the result that they have been difficult to maintain efficiently. Their mileage has also been relatively low, causing unit costs to rise. The dip in the curve for 1931 was caused by a relatively high mileage for that year. Curve 4 shows what has been accomplished in the reduction of lubricating oil costs, particularly in the Beardmore six-cylinder engines, by adding one more ventilated type scraper ring to the piston above the gudgeon pin, and providing greater drainage through the piston itself; by reducing the piston skirt clearance as well as those of the main bearings; and by improving the quality of the fuel oil.

In an effort to determine the proportion of equipment failures which were due to the use of the compression-ignition engine, a careful analysis was made of all reported troubles on the 28 railcars since January 1, 1931, to the end of October, 1933, with the following results:—

Electrical—including storage battery and lighting system	32 per cent.
Mechanical—including the engine with its fuel, lubricating oil and water systems	56 ,,
Car—including trucks, brake gear and car heating	12 ,,

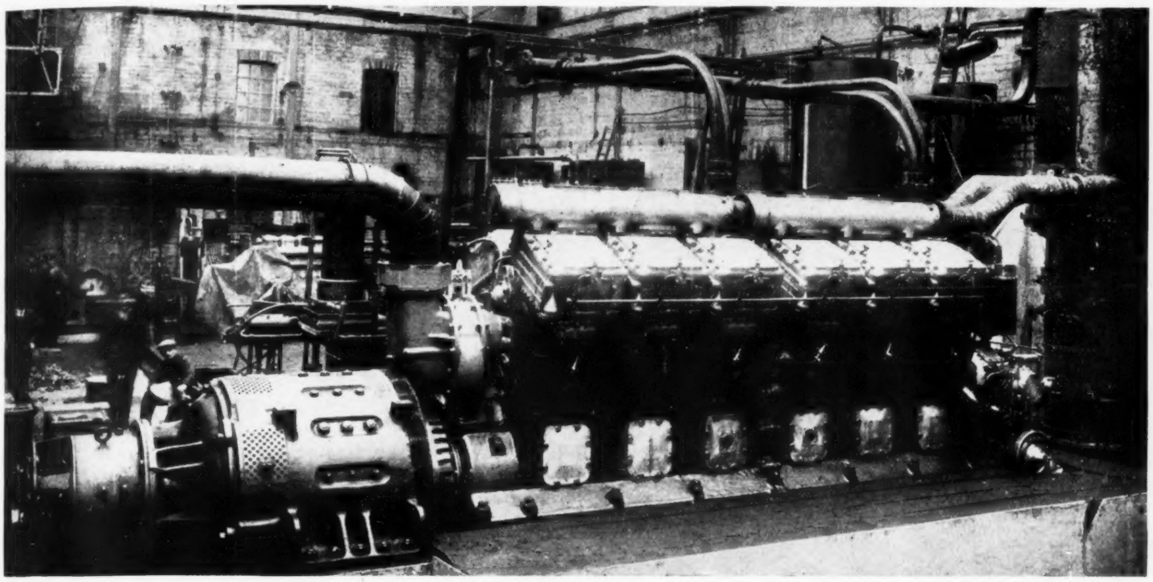
The total mileage made by these 28 cars during the time under analysis was 3,404,477.

In reviewing the causes of the engine failures in the light of experience in service, it is interesting to note how few they really are. At first it is often difficult to recognise the primary cause, which may be ascertained only by a process of elimination, carried out too frequently in a very unscientific manner. As an example, the big

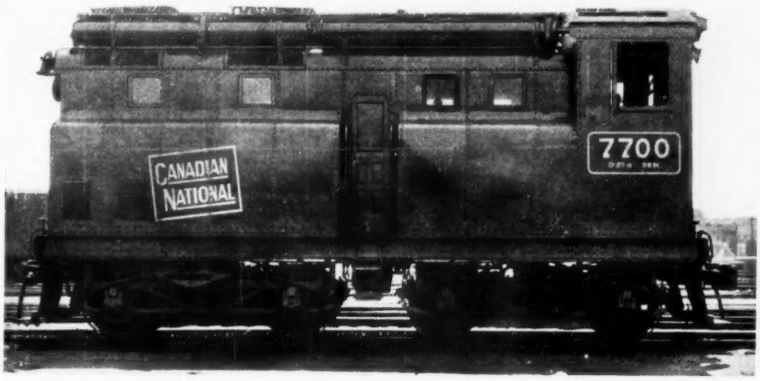


Mileage record since 1925 of the five types of Canadian National railcars

Double-bogie 73 ft. car with 300 b.h.p. Beardmore engine, Canadian National Railways

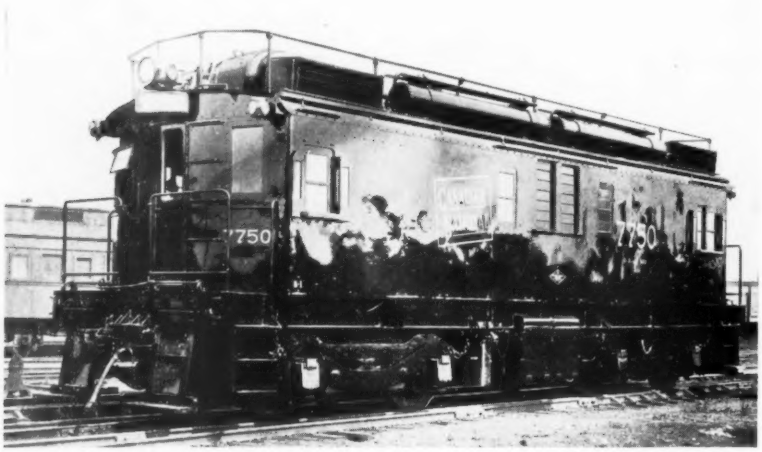


Above: Beardmore 1,330 b.h.p. 12-cylinder oil engine of the type used on the Canadian National Railways. The supercharger seen in the illustration has been removed



Right: Double-bogie oil-electric shunting locomotive with 400 b.h.p. Westinghouse-Beardmore engine

Below: One of the 300 b.h.p. railcars fitted up as a baggage and mail van



Canadian National 600 b.h.p. shunting locomotive fitted with two Ingersoll-Rand engines

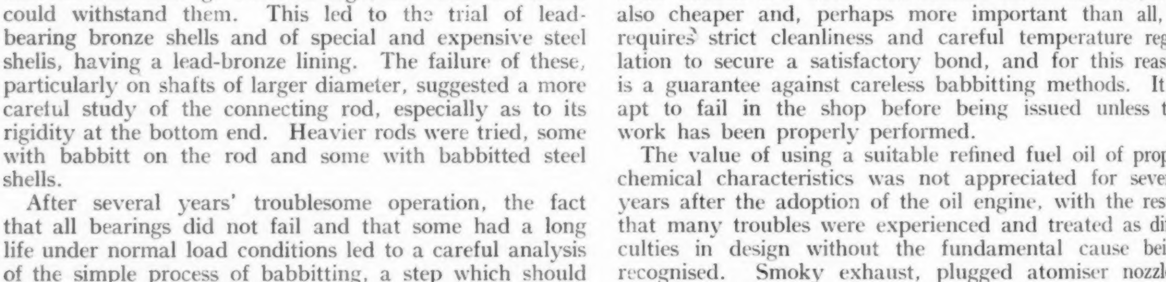
end bearing failures were a considerable source of worry and concern. The first thought, perhaps naturally, was that the unit loadings were too high, and that no babbitt could withstand them. This led to the trial of lead-bearing bronze shells and of special and expensive steel shells, having a lead-bronze lining. The failure of these, particularly on shafts of larger diameter, suggested a more careful study of the connecting rod, especially as to its rigidity at the bottom end. Heavier rods were tried, some with babbitt on the rod and some with babbitted steel shells.

After several years' troublesome operation, the fact that all bearings did not fail and that some had a long life under normal load conditions led to a careful analysis of the simple process of babbitting, a step which should have been taken at first. The reason why this was not taken was, perhaps, due to the fact that the light weight, high speed engine in railway working had many critics in the engineering profession, and among these were some of the manufacturers themselves, and suggestions were rife as to the doom which was ahead of this foolish attempt. However, it soon became evident that the ordinary shop practice was not good enough and that babbitted bearings were being turned out in which there was very poor adhesion between the babbitt and the bronze shell. It was necessary to establish a new practice in which the temperature of the babbitt and of the shell and of the jig is definitely controlled, and the chance of oxidation and the inclusion of impurities are reduced to a minimum.

Reduction of Bearing Failures

Thanks to the use of a special babbitt, and the establishment by the railway of proper methods of application, bearing failures are now very rare, and the questions of the flexing of rods or excessive bearing loads have been forgotten. Lead babbitt is a better anti-friction metal than tin; it is also cheaper and, perhaps more important than all, it requires strict cleanliness and careful temperature regulation to secure a satisfactory bond, and for this reason is a guarantee against careless babbitting methods. It is apt to fail in the shop before being issued unless the work has been properly performed.

The value of using a suitable refined fuel oil of proper chemical characteristics was not appreciated for several years after the adoption of the oil engine, with the result that many troubles were experienced and treated as difficulties in design without the fundamental cause being recognised. Smoky exhaust, plugged atomiser nozzles, excessive lubricating oil consumption, excessive piston and liner wear, high water and lubricating oil temperatures



Longitudinal section of the Beardmore six-cylinder 300 b.h.p. engine as used in the Canadian railcars

are all aggravated by the use of an inferior fuel. At last realising this fact, the Canadian National engineers, in consultation with the oil company's chemists, established a new fuel specification based on the particular requirements of the oil engine and emphasising the chemical characteristics, such as initial boiling point, distillation temperatures, &c., rather than on the old bases of viscosity and gravity, which can mean so little from the standpoint of good combustion.

Experience with the oil engines in switching service on the Canadian National Railways is limited to two locomotives, a 62-ton unit fitted with a Westinghouse-Beardmore variable speed 9 in. by 12 in. engine, developing 400 b.h.p. at 900 r.p.m., and a 107-ton unit fitted with two 10 in. by 12 in. Ingersoll-Rand engines, each developing 325 b.h.p. at 550 r.p.m. The first of these has been in service for four years and the latter for one year and nine months.*

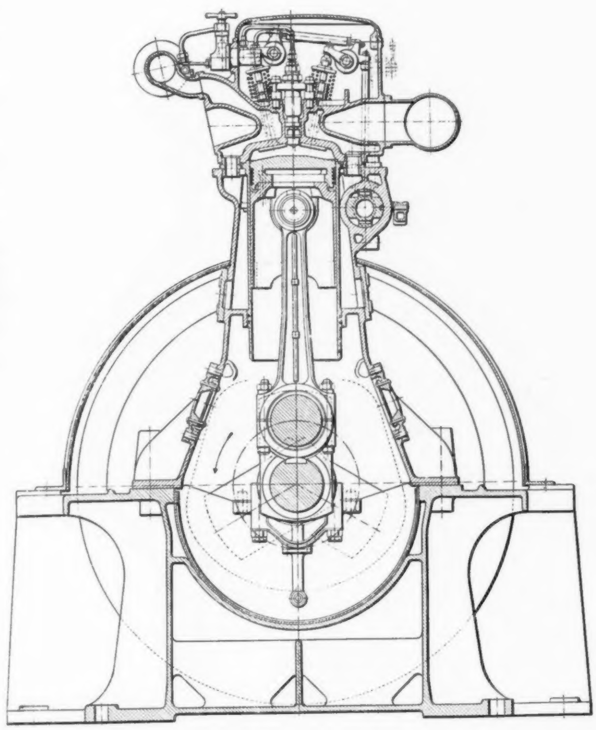
There is no doubt as to the usefulness of this type of locomotive for switching service, and it is in this class of working where the largest savings can probably be made. Owing to the greater hours in service, to the reduction in stand-by losses, and to the lower operating costs, including the reduction in crew wages by the elimination of the fireman, a handsome saving can be made in 24-hr. service which will more than compensate for the present too heavy capital cost.

Careful attention should be given to the selection of the engine for switching locomotives. In the writer's opinion, it should be as rugged and conservative in design as the horse-power-space ratio of the locomotive will permit, and it should run as nearly as possible at constant speed. By observation and test it is found that at least 90 per cent. of the yard switching movements are made at 5 m.p.h. or less, which means that the variable speed engine is rising and falling through its speed range almost constantly. For this class of working it would seem much better to control the speed of the locomotive electrically with a constant-speed engine rather than utilise a variable-speed engine.

The only experience that the Canadian National has had with oil engines in main-line service is that gained with the two locomotive units 9000 and 9001, which are each fitted with Beardmore 12-cylinder V engines with a bore and stroke of 12 in. and developing 1,330 b.h.p. at 800 r.p.m. The weight of this engine without bedplate and generator is 23 lb. per b.h.p., or complete with bedplate and generator 44 lb. per b.h.p. The cabs are designed to operate from one end only, but when coupled together the combined locomotive operates from either end. One unit was fitted with a supercharger of the turbo-blower type, but owing to its excessive noise it was removed.

In a recent paper before the Canadian Railway Club, Mr. A. I. Lipetz, Consulting Engineer for the American Locomotive Company, called attention to the difficulties in operating a single locomotive of any special design, whether steam or diesel, owing to its being different from all others and to the difficulty in fitting it into the regular and sometimes conservative conditions of operation and maintenance. No. 9000 has been the ugly duckling of the Canadian National, and its life since 1927 has consequently not been the happiest. The two units have worked separately and coupled in both passenger and freight service, partly between Toronto and Montreal, a distance of 334 miles, but mostly from Toronto to other points in Ontario. The original crankcases proved too light and were replaced in 1931 by the manufacturers, adding about 1·5 lb. per b.h.p. to the weight. Reviewing the operation

* These units have been illustrated and described in the *Diesel Railway Traction Supplement* for February 23, November 3, and December 1, 1933.



Cross-section of Beardmore 300 b.h.p. engine

since this reconditioning, the three chief causes of trouble were the inferior quality of the fuel (not then recognised as troublesome), high lubricating oil consumption, and big end bearing failures. One or all of these resulted in a broken piston in 1932 and both units were withdrawn and remained out of service until July, 1933, since which time unit 9001 has made 28,670 miles with relatively satisfactory results, and unit 9000 is being reconditioned at the time of writing.

Having rectified the troubles due to poor fuel and improper babbitting of big end bearings, as explained in detail in connection with the unit railcars, it is fully expected that the third chief difficulty of high lubricating oil consumption will be greatly improved by the application of modified pistons, similar to those which have been found so beneficial in the Beardmore six-cylinder engines as evidenced by B-6 in the fourth set of curves given above.

The operating data on the single unit 9001, in local passenger service since July, 1933, are as follows:—

Oil-Electric Locomotive 9001
(Single Unit)
July 1933, to March, 1934 inclusive

Locomotive miles		28,670
Coach miles		114,473
Gallons, fuel		30,374
Gallons, lub. oil		4,650
Miles per gallon (fuel)		0·94
Miles per gallon (lub. oil)		6·17
Supervision per loco. mile	(cents)	2·0
Repairs ,, ,, ...	,,	29·0
Fuel ,, ,, ...	,,	7·66
Lub. oil ,, ,, ...	,,	11·85
Other oils and greases per loco. mile ..	,,	1·36

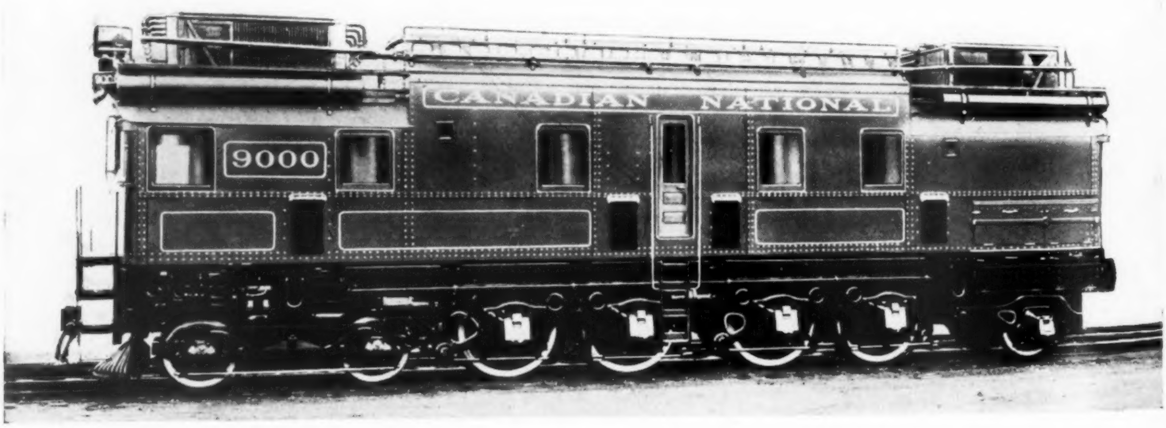
In the item of repairs is an amount of 6·28 cents, covering the wages of a maintainer who is assigned to these units

but who should take the place of the fireman in regular service, and is therefore a legitimate deduction from the cost of maintenance for this comparison. This is an operating problem involving the train crew's working schedules, which has not yet been adjusted and is not an engineering one, as to the suitability of the locomotive. Professor Lomonossoff made rather pointed reference to this condition in his paper " Diesel Traction " before the Institution of Mechanical Engineers in Manchester last October, but failed to apply his information correctly. The small mileage quoted by him was in no way due to the inexperience of the locomotive crews although the cost per train-mile was augmented by the wages of the unqualified fireman. The locomotive, however, was always attended by a qualified maintainer.

The indications on the Canadian National are that the most useful oil engine equipment of the future is a locomotive of from 600 to 800 b.h.p. capacity, by the use of which the entire steam operation on branch lines and unimportant divisions can be replaced. The single railcar of 350 b.h.p. capacity is not large enough to handle the extra express car on a passenger schedule or take care of the infrequent mixed freight service. Diesel equipment which can do this seems to be the logical next step to meet the present depleted traffic conditions. The oil-electric switching locomotive has proved itself on many railways, and, in the writer's opinion, will not radically change in the near future. The many claims of the advantages of the torque converter instead of electric traction seem poorly made after considering the comparative efficiencies and the complications set up by the very frequent reversals in the direction of the locomotive in switching service.

The application of the torque converter and the fluid flywheel in high speed running, on the other hand, is quite a different proposal and one which would seem to have a real advantage over electric transmission. It would be interesting therefore to see an installation of a 400 b.h.p. drive and to know the comparative weight and cost. After all is said and done, it is the present cost of the electric drive which is its chief disadvantage, and it is the carrying charges on the high capital costs of the complete railcar or locomotive which are the railway engineer's greatest present concern.

Canadian National 2,660 b.h.p. diesel-electric articulated locomotive on passenger train. The illustration shows the locomotive in its original form



Canadian National 1,330 b.h.p. diesel-electric locomotive as now running, that is, with the articulated locomotive in the top illustration as two separate units

DIESEL-WORKED PASSENGER AND GOODS SERVICE

Small British railway makes big savings by introducing four-wheeled electric transmission unit with light-weight engine

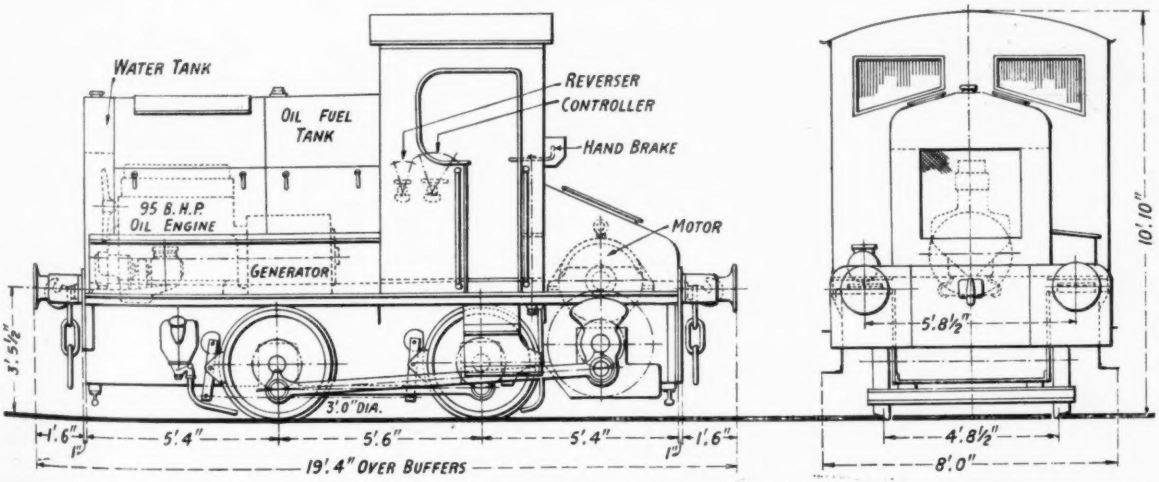
95 b.h.p. diesel-electric locomotive on the North Sunderland Railway

SOME months ago the North Sunderland Railway, running from Chathill on the Newcastle-Berwick main line of the L.N.E.R. to Seahouses on the Northumberland coast, decided upon the adoption of diesel traction for the sake of economy in operation, and under the direction Mr. S. W. Meyer, Managing Director, ordered a diesel-electric locomotive from Sir W. G. Armstrong-Whitworth & Co. (Engineers) Ltd. This was delivered a short while back, and is shown in the accompanying illustrations.

While this locomotive was under construction, traffic was operated by the 15-ton 95 b.h.p. diesel-electric locomotive shown by Armstrong-Whitworth at the Shipping and Machinery Exhibition in 1933, and the data obtained during this period indicated that operating expenses could be cut by about £300 a year. The two locomotives are of the same weight and power, but differ in the layout of the equipment and in the arrangement of the drive.

In the course of the first five months of its work on the North Sunderland Railway, the exhibition locomotive covered approximately 6,000 miles, hauling trains composed of one or two carriages and one or two wagons. The heaviest load hauled over the 4¼ miles separating the two termini was 90 tons, but a maximum load of over 200 tons was shunted. A weekly mileage of approximately 280 was covered with a fuel consumption of about 66 gal., an engine lubricating oil consumption of 4½ gal., and 2 pints of lubricating oil for the mechanical portion. Taken over a week, the time spent in preparing and adjusting the locomotive amounted to 6-8 hr. Only one set of new brake blocks was required during the time the locomotive was working on the line, and two pistons and one cylinder head were replaced. In this connection, however, it must be remembered that the locomotive had done a considerable amount of work previously, including a spell of heavy duty in a steel mill at Scunthorpe. (See the *Diesel Railway Traction Supplement* for May 18 last.)

Traffic on the North Sunderland Railway does not require speeds in excess of 25 m.p.h., and even this rate is not often attained under normal conditions. When working trains of 60-65 tons, to the ordinary schedule, accelerations from rest to 15 m.p.h. in 24-26 sec. are the rule. Fuel is supplied to the locomotive from a tank holding 8-10 tons of fuel, which was converted from the water tank used for the old steam locomotive. The exhibition locomotive has a tank capacity of 40 gal., but the new locomotive has a tank capacity of 120 gal., sufficient for nearly two weeks of normal work.



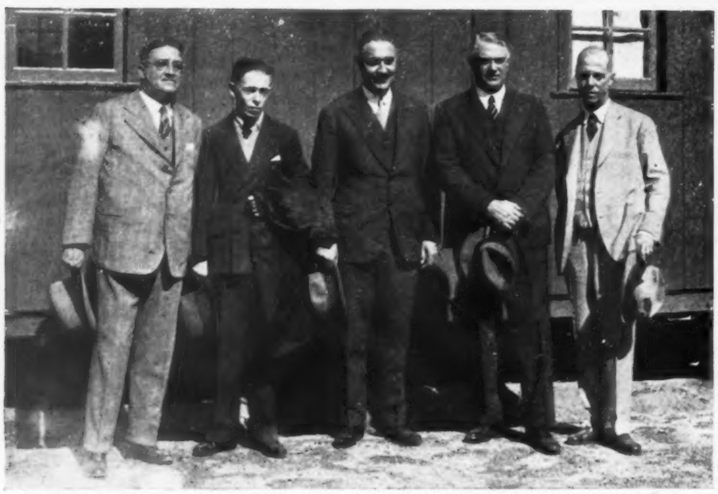
General arrangement of diesel-electric locomotive with high-speed Armstrong-Saurer engine

INAUGURATION OF BRAZILIAN DIESEL SERVICE

British-built unit provides luxurious train service between two important towns

AFTER several months of extensive experimental running, the diesel-electric train supplied at the turn of the year by Sir W. G. Armstrong Whitworth & Co. (Engineers) Ltd. to the San Paulo Railway, and described in detail in the *Diesel Railway Traction Supplement* for December 1, 1933, has now gone into regular operation, and the inauguration of the new service was marked on June 25 by a ceremony attended by a number of Government and railway representatives. In the morning the assembled company left the Luz station at San Paulo, and proceeded in a special train to Alto da Serra, where, on the arrival of another party of guests from Santos, the machinery for hauling trains up and down the cable-worked Sierra section was inspected. An inspection was then made of the diesel-electric train and of old and new rolling stock drawn up alongside, and which included a 69-year old steam engine, an express Beyer-Garratt locomotive, and the old coach of Emperor Dom Pedro II.

At the conclusion of this inspection the guests boarded the diesel-electric train, and Dr. Francisco Machado de Campos, Brazilian Secretary of Transport, deputising for the Federal Interventor for the State of San Paulo, drove the train a distance of some 200 yd. and declared the diesel service officially opened. Luncheon was served in four of the railway company's dining cars, and during its course Mr. A. M. Wellington, Superintendent of the San Paulo Railway, referred to the benefits which he hoped the Comet (as the train has been styled by the owning company) would confer upon the public, and stated that the new type of traction, of which it formed the first Brazilian example, had boundless possibilities. The company present included, in addition to the above-named, Colonel Mendonça Lima, Director of the Central Railway of Brazil, representing the Minister of Communications; Sr. Heitor Freire de Carvalho, and Sr. Jayme Cintra, of the Paulista Railway; Mr. A. G. Ponsonby, Acting British Consul-General in San Paulo; Colonel P. T. Etherton, and representatives of other Brazilian railways, public bodies, and the press. In the afternoon the Comet made a trip from Alto da Serra to San Paulo and covered the distance of 48 km. (30 miles), abounding in sharp curves and undulating grades, in 35 min., or at an average speed of 82 km.p.h. (51 m.p.h.). A maximum speed of 108 km.p.h. (67 m.p.h.) was attained, and the running was notable for its smoothness. Regular diesel operation



Top: Inauguration of the new diesel-electric service by the Brazilian Secretary of Transport. Bottom: Mr. A. M. Wellington, Superintendent of the San Paulo Railway (extreme left), with the General Managers of the Paulista and Central of Brazil Railways and representatives of the Federal Inspectorate. Right: Vehicles of San Paulo diesel train being lifted by 500-ton crane for shipment from England

Left: The San Paulo Railway's diesel-electric train, the Comet, running between San Paulo and Alto da Serra

Below: The inauguration ceremony at Alto da Serra of the new express diesel-electric service from San Paulo to Santos on the San Paulo Railway, Brazil. The company present at the ceremony included a number of prominent Brazilian Government and railway officials

over the S.P.R. main line commenced on July 1, when the Comet was substituted on weekdays for the 8.00 a.m. steam train from San Paulo and the 10.00 a.m. and 5.00 p.m. services from Santos. A new train leaving San Paulo at 1.00 p.m. has also been put on, and provides the return working for the Comet. The 10.00 a.m. train from Santos is being worked on an accelerated schedule of 97 min. for the 79 km. (49 miles) including the negotiation of the Sierra. The other trains are being worked on overall timings varying from 101 to 102 min., and all will run non-stop, apart from the halts at the top and bottom of the cable section. Although it is expected that when the line has been re-aligned for high speeds the overall time will be reduced to slightly under 90 min., further acceleration can hardly be expected, as the time taken in negotiating the Sierra can be cut very little from the present schedule of 41 min., despite a shortening of the stops at top and bottom.

Since being constructed in Britain, the seating accommodation has been modified. The train now contains 84 first class seats in the two end vehicles, and the centre portion has been fitted up as a *de luxe* car seating 19 passengers in a smoking room and lounge. The smoking room has a buffet-bar for the supply of drinks and light refreshments, and the lounge has a small library. Standard first class fares are being charged for travel in the ordinary portion of the train, with a supplement of two milreis for the use of the *de luxe* car.

NOTES AND NEWS

Belgian Diesel Inquiry.—The Belgian National Railways is now considering tenders for 12 diesel-electric triple-articulated railcars with a total engine power in the neighbourhood of 800 b.h.p. The maximum speed of these cars will be approximately 93 m.p.h. (150 km.p.h.).

More Asiatic Railcars.—The Regie Générale de Chemins de Fer et de Travaux, which controls the Syrian railways, has ordered four 210 b.h.p. diesel railcars for service between Aleppo and Rayak and from Homs to Tripoli. They are to be delivered by October next, and it is reported that they are to be suitable for a maximum speed of 50 m.p.h.

Another Diesel Locomotive for Sudan.—An order for a diesel shunting locomotive of 190 b.h.p. has just been placed with Harland & Wolff Limited by the Sudan Railways. It will be generally similar to the locomotive now under construction for the L.M.S.R., with modifications to suit it for operation in a sand-laden atmosphere with a temperature up to 150° F.

Diesels for Indo-China.—Five diesel railcars have been ordered for passenger service on the Yunanfou Railway in Indo-China. They are to be equipped with 95 b.h.p. six-cylinder Saurer diesel engines, and the mechanical portions will be built in France. By their use it is hoped to increase the average speed between Haiphong and Hanoi to nearly 50 m.p.h., in place of the 25 m.p.h. of the present steam trains, and to reduce by half the journey time of two days between Hanoi and the railhead at Yunnanfou.

The Largest Diesel Locomotive.—Tenders are now being submitted to the Paris, Lyons & Mediterranean Railway by several well-known Continental firms for a main line diesel-electric locomotive of 3,500 to 4,000 b.h.p. A feature of the designs is that Büchi supercharging is incorporated. The design for a locomotive such as this was illustrated in the issue of the *Diesel Railway Traction Supplement* for January 27, 1933.

Nord Diesel Programme.—The two triple-unit Maybach-engined diesel-electric trains just acquired by the Nord, and described in detail in the issue of this Supplement for July 13, began regular operation over the Paris-Lille line on July 27. During the course of preliminary trials, a speed of 90 m.p.h. was attained, and on a slight down grade the train was brought to rest from this speed in a time of 36 sec. and in a distance of 930 yards. No fewer than 10 similar trains are to be ordered from the Société Franco-Belge de Materiel de Chemins de Fer, the builders of the two trains now at work.

Another American Diesel Order.—News that a high-speed streamlined passenger train will be built for the Illinois Central system for operation between St. Louis and Chicago was announced on June 14 upon approval of a loan for that purpose by the Public Works Administration. The loan will be for approximately $2,000,000, of which $500,000 will be for the streamlined train and $1,500,000 will be for the purchase of eleven diesel freight locomotives. The diesel locomotives represent a further step in the progressive elimination of steam operation in the Chicago terminal.

The streamlined train will be designed and built to fit the needs of day-time operation on the run between Chicago and St. Louis, and will be air-conditioned and thoroughly modern in every respect. The schedule of the new train is under consideration. All that can be said at the moment is that the running time will be materially faster than the present fastest schedule between the two cities, which is 6½ hr. It is the intention to have the train make a round trip daily. The best that has been done with passenger equipment in steam service is one trip in one direction each 24 hr.

Armstrong's Chairman on Diesel Traction.—At the recent annual meeting of Armstrong Whitworth Securities Co. Ltd., the Chairman, Major-General Guy P. Dawnay, said: "I venture to think that our name is recognised as one of the leaders in diesel traction, the development of which has steadily advanced. I believe railway authorities realise that it has passed the experimental stage, as evidenced by the results of trial units we have supplied. The London & North Eastern Railway have taken two more railcars after 18 months' trials of the *Tyneside Venturer*. Gratifying reports have been received regarding the 450 b.h.p. train delivered to the San Paulo Railway and of the 1,700 b.h.p. units to the Buenos Ayres Great Southern Railway.

Our Vice-Chairman visited South America this year and reports increasing interest in diesel traction. The volume of orders, however, has been slow in materialising, owing to depressed trade and traffics and exchange difficulties. Serious inquiries are, however, being received. Indian railways are also seriously interested. We have obtained an order for two 1,300 b.h.p. diesel-electric locomotives for the Karachi-Lahore mail service. This I regard as important, as it is hoped to establish a universal unit to suit the needs of all Indian railways where favourable conditions exist. We have orders for railcars for the Madras & Southern Mahratta Railway and a diesel locomotive for Ceylon, while the Kalka-Simla Railway and the Great Indian Peninsula Railway have a rail coach each."

HIGH SPEED TRAINS FOR DENMARK

Articulated units following the lines of the Flying Hamburger and Netherlands Railways trains have been ordered by the Danish State Railways

FOR eight years the success of diesel traction in operating local and light traffic in Denmark has been unquestioned, and since 1932 the two 1,000 b.h.p. Frichs locomotives have given evidence that express traffic of the type found in Jutland can be economically worked by the same form of traction. On the whole, however, railcars appear to be more suited to Danish conditions, and the ten 480 b.h.p. semi-streamlined double-bogie vehicles introduced since the turn of the present year, and described in this Supplement for March 23, have proved their ability to work light trains at speeds up to 75 m.p.h.

Even faster services between Copenhagen, Esbjerg, and Aarhus are envisaged by the management of the Danish State Railways and, following the policy of purchasing no further steam locomotives, four high-speed triple-articulated trains have been ordered from A/S Frichs, which firm has played a leading part in the introduction and perfecting of diesel traction on the various Danish lines. The design is a combination of the different features of the Flying Hamburger and the 40 trains now running on the Netherlands Railways, as described in the May 18 issue of this Supplement. Like the Dutch units, the Danish trains are to be of triple formation with four nose-suspended traction motors mounted on the two inner bogies. The diesel engines are mounted on the end bogies, according to Frichs standard design.

Power Equipment

The power plant and bogies are to be constructed by Frichs, the bodies by the associated Scandia Car Works, and the electrical equipment by A/S Titan, of Copenhagen, Frichs acting as main contractors for the whole order. As may be seen from the accompanying drawing, the overall length is to be over 200 ft. The estimated tare weight is 118 tons, or about 28 tons more than the Dutch trains, which, in practically the same length, seat 160 passengers in two classes, compared with 152 in the Danish trains. With an output of 1,100 b.h.p. the power-weight ratio of the latter is thus 9·35 b.h.p. per ton of tare against 9·1 b.h.p. of the Netherlands trains. The main comparative particulars of the two types are as follow, the Danish figures in all cases being the estimated values:

Train		Dutch.	Danish.
Formation		Triple	Triple.
Power plant carried		In centre car	On end bogies
Overall length		203·75 ft.	209 ft.
Seating capacity—			
First class		12	36
Second class		148	116†
Total		160	152
Number of engines		2	4
Total b.h.p.		820	1,100
Tare weight,	tons	90	118
B.h.p. per ton of tare		9·1	9·35
Weight per seat	lb.	1,255	1,740
Max. speed, m.p.h.		90*	75

* Maximum in present service does not exceed 62 m.p.h.

† Including 12 in restaurant.

At each extremity of the train is a driver's compartment, and next to it an engine room containing a double diesel dynamo set. These engines are somewhat similar to the 240 b.h.p. engines installed in the recent 480 b.h.p. diesel-electric railcars, but the rating has been increased to 275 b.h.p. at the same rotational speed of 1,000 r.p.m. They will be of the four-stroke type, arranged to work at 475, 850, and 1,000 r.p.m., in order to render the train as efficient as possible at reduced loads and speeds. For the maintenance of any of these speeds at varying loads, the voltage of the main generator will be altered by means of a shunt resistance.

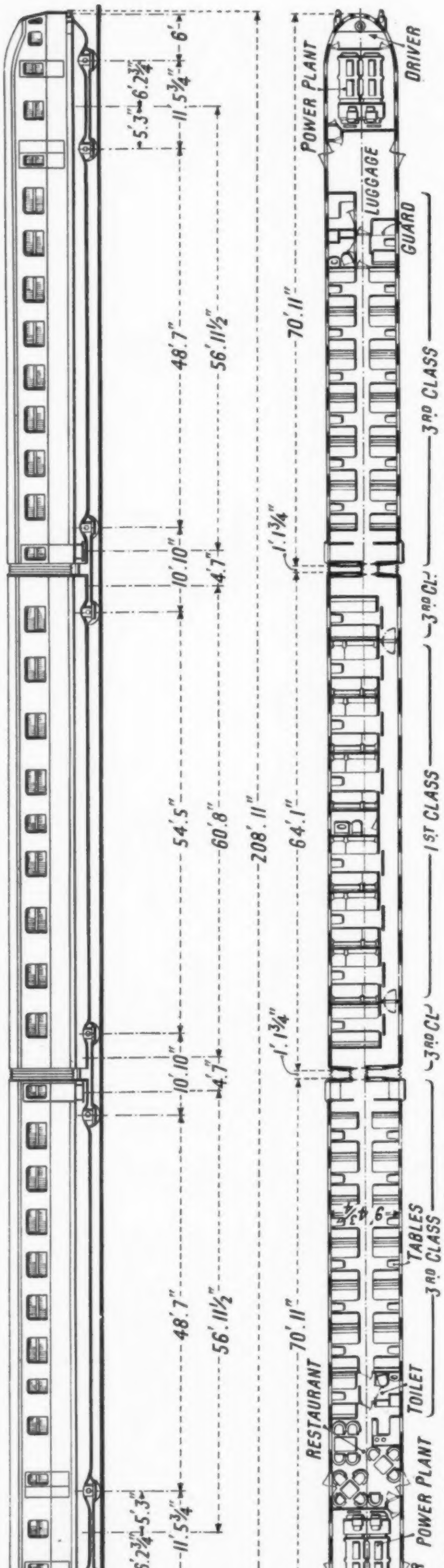
Directly coupled to each engine will be a compound-wound d.c. main generator with a belt-driven auxiliary generator above it, and the complete power unit will be mounted on the end bogie with the engine beds level with the floor. By a special patented arrangement the engine and bogie can be hauled out of the coach for repairs, and

Interior of 480 b.h.p. Danish railcars
A similar style of seating and decoration will be used for the new 1,100 b.h.p. high-speed trains

the arrangement has the further advantage claimed for it that the vibrations from the diesel engines are not transmitted to the passenger compartments. The auxiliary generator, in addition to exciting the main generator fields, will provide current, in conjunction with a storage battery, for the auxiliaries, including the air-brake compressor and the engine cooling water pumps. The engines are to be started electrically, the main generator acting as a motor when supplied with current from the battery, which is to have a capacity of 258 amp. hr. at the five-hour rate of discharge.

Cooling System

The fuel supply to the engines is to be regulated automatically in order to facilitate control from either end of the train. The cooling system for the engine will consist of gilled tube radiators located in the roof, but owing to the streamlined contour of the train there will be no natural draught, and electrically-driven fans are to be fitted to keep the cooling water outlet temperature to 140 deg. F., which is a normal figure for rail traction diesel engines of this size. Apparently the present intentions are



1,100 b.h.p. diesel-electric triple-articulated streamlined trains now under construction at the Frichs works at Aarhus for the Danish State Railways. They will maintain a fast service between Copenhagen and the big towns of Jutland, running via the Korsor-Nyborg train ferry and the Little Belt bridge

that the hot water will pass to a tank before going to the radiator, and after being cooled there will go to another tank before returning to the engine jackets, a slightly different arrangement from that usually fitted.

The main generators are to be separately excited dynamos with reversing poles and main current starter winding. They will each have a continuous capacity of 200 kW. at 720 volts and 1,000 r.p.m. and will have a short time rating of 500 amp. when starting. The auxiliary generator attached to each power set is to be driven by three rope belts and will have a capacity of 8 kW. They are to be supplied with a weak differential compound winding and a variable resistance from the shunt circuit, so that they can charge the battery at all three speeds of the diesel engines. The traction motors are to be of the self-ventilated series-wound protected type with a continuous output of 140 kW. each at 720 volts and 2,000 r.p.m. They will be regulated in the normal way by means of the main generator voltage and field resistances, and each will have an easily removable cover to facilitate inspection of the commutator and brush gear.

Each driving compartment will contain the necessary apparatus for starting and stopping individually the four diesel engines, a reversing handle, and a control lever for varying the engine speed and so the voltage of the auxiliary generators, enabling the batteries to be charged at all three engine speeds. Indicating lights for the cooling water and lubricating oil circuits, a thermometer for the cooling water, a speedometer, and the usual brake handles and gauges will also be installed in each driving compartment, and a dead-man device with both hand and foot control is to be incorporated.

Layout of Passenger Accommodation

Next to one engine room will be located a restaurant or buffet, and next to the other a luggage compartment, both of which will be separated from the adjoining engine room by a double sound-resisting panel. The luggage compartment is to be arranged in such a manner that it can be fitted up as an additional restaurant. The first-class accommodation will be in the centre car only, and the third, or common class as it is now styled in Denmark, will be provided in all the vehicles. Apart from a stipulation that the seats should be of the high-braked type covered in leather, the interior decoration is not yet settled in detail. The seats will be of similar type to those used in the present 480 b.h.p. railcars as shown by one of the accompanying illustrations.

Braking is to be effected on the automatic air system, and blocks will be applied to drums attached to all the wheels, with a force equivalent to 85 per cent. of the tare weight. A hand-controlled hydraulic brake to be worked from both driving positions is to be fitted, and proposals to fit an additional electro-magnetic brake are now under consideration.

It is intended that when the trains begin to operate on the Copenhagen-Jutland services they will run straight on to the train ferry at Korsor and off again at Nyborg, whence they will start non-stop runs to either Aarhus or Esbjerg *via* the new Little Belt bridge. A time of 4 hr. 30 min. between the Danish capital and Aarhus, a distance of 220 miles including a ferry stretch of 16 miles, which now takes 70 min., is proposed, giving an average rail speed of almost 60 m.p.h., and to attract further traffic it is probable that the trains will be painted in striking colours and named.

As we have previously noted in these columns, the builders of these new trains, A/S Frichs, of Aarhus, recently entered into a collaboration arrangement with the Vulcan Foundry Limited, of Newton-le-Willows, for the construction of diesel locomotives and railcars.

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